PATENT SPECIFICATION (11) 1 502 919

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(21) Application No. 53033/75 (22) Filed 29 Dec. 1975
(31) Convention Application No. 50/034385
(32) Filed 24 March 1975 in
(33) Japan (JP)
(44) Complete Specification published 8 March 1978
(51) INT CL² F26B 11/02
(52) Index at acceptance
F4G 1C4 1M2 2C1B

(19)

(54) CLOTHES DRIER

(71) We, HITACHI, LTD., a Corporation organised under the laws of Japan, of 5—1, 1-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a clothes drier, which removes moisture contained in clothing therefrom by the use of heated air, and more particularly to a clothes drier which uses a thermistor having a positive temperature coefficient (hereinafter referred to as a PTC thermistor) as a heat source. Such a PTC thermistor is described in United States Patent Specification No. 3,927,300.

Among many types of heat sources for use in drying the clothing in the driers of a conventional type, those utilizing gas or electricity find the practical applications. Particularly, the heat sources utilizing electricity enjoy good reputation from viewpoints of ease in control, and improved safety in the event of troubles in the driers, and accordingly find a wide use. One of those is disclosed in the United State Patent No. 2,958,138 which is associated with a clothes drier.

Meanwhile, the driers using electric type heat sources, in general, adopt a ferrochrome wire in the form of a coil as an electricity-to-heat converting means. In this respect, the quantity of heat generated in a heat generating body in a drier of this kind is proportional to the product of an ohmic resistance and the square of a current. In general, the heating value of a heat generating body consisting of a ferrochrome wire in a clothes drier is on the order of 1.2 KW. For the convenience of household, the heating value to be generated in the drier is classified into two classes, i.e. 1.2 KW and 0.8 to 0.6 KW, and thus a switch is provided so as to switch the heating value one class to another, commensurate to the quantity of clothing to be dried.

With the clothes drier, which uses a ferrochrome wire heater, the heating value to be generated per unit area is so set that the surface temperature of a heat generating body will not exceed about 300°C by cooling same with air being fed.

Meanwhile, the drying time of clothing in a drier varies with the kinds and quantities of clothing to be dried, the degree of drying of clothing, atmospheric temperature, humidity, flow rate of air passing through a cabinet, capacity of heat generating device and the like.

With the clothes drier, which uses a ferrochrome wire heater, the user takes into consideration the aforesaid various conditions and determines a drying time by experiance so as to set a timer for drying the clothing.

This leads to disadvantages, such as an excessively short drying time or an excessively long drying time for clothing to be dried in a drier.

Meanwhile, the prior art drier of this kind uses a ferrochrome wire heater, and a filter means located in the upstream of a discharge port adapted not to discharge dust from the interior of a rotary drum, thereby collecting dust on the aforesaid filter means. For this reason, in case the filter means causes a clogging phenomenon, the flow rate of air passing through the cabinet is lowered, thus incurring a possibility of the ferrochrome wire heater being subjected to overheating. To cope with this, there is provided a protective means such as a thermostat in a drier, thereby cutting off a power source prior to the occurance of overheating in the ferrochrome wire heater. In addition to this, there is provided a safety means, such as for instance, a thermostat, in the close vicinity of the path of streams of exhaust air, in an attempt to adjust the temperature so that the clothing will not be subjected to an excessively high temperature. This however causes many problems in attaching such protective means, such as a thermostat, within a cabinet of a small size, thus resulting in complexity of construction.

It is accordingly an object of the present invention to provide a clothes drier, which permits a positive, automatic drying operation, due to the fact that, when the flow rate of air is reduced due to dust or pieces of

clothing clogging in a filter, the quantity of heat being generated is reduced, and which may be controlled for the completion of drying, commensurate to a temperature rise of exhaust air. It is another object of the present invention to provide a clothes drier, which provides high safety by automatically preventing the overheating of a heat generating means, in case the flow rate of air being introduced is reduced, without resorting the use of a thermostat.

It is a further object of the present invention to provide a clothes drier, which is compact in size and dispenses with a protective means such as a thermostat.

According to the present invention there is provided a clothes drier, comprising: a cabinet; a container which is rotatably supported within said cabinet, and has an opening; drive means for rotating said container provided within said cabinet; blower means for feeding air from the exterior of said cabinet into said container and connected to said drive means; heat generating means including electrically resistive means for heating air being introduced into said cabinet by means of said blower means and for generating heat of a quantity proportional to a predetermined range of quantity of air being introduced, whereby said heat generating means provides an adjustable temperature of said heat generating means and of heated air exhausted from said container for preventing overheating of said heat generating means and clothes in said container without requiring thermostats; and exhaust means for discharging heated air from said container outside of said cabinet.

Preferably a PTC thermistor is used as the heating generating means of the clothes drier.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal cross-sectional view of a clothes drier, which embodies the present invention;

Figure 2 is a diagram illustrative of the paths of air streams being passed through the drier of Figure 1;

Figure 3 is a plot representing the temperature of exhaust air at varying drying times in the drier of this kind;

Figure 4 is a plot representing the temperature rise of exhaust air at the completion of drying in the drier of this kind, at varying drying times;

Figure 5 is an electric circuit diagram of the drier of Figure 1;

Figure 6 is a characteristic curve of the heating value of a heat generating means for use in the drier of Figure 1 at varying flow rates of air; and

Figure 7 is a characteristic curve illustrating the relationship between the ratio of the heating value generated in a heat generating means for use in the drier of Figure 1 to the flow rate of air, and the flow rate of air itself.

Referring now to Figure 1, a cabinet 1 consists of a front panel 2 having an opening, a rear panel 3 and an enclosure member 4 interconnecting the front panel 2 and the rear panel 3. The construction of the cabinet 1 is of a rectangular parallelepiped shape, presenting desired rigidity.

Rotatably mounted within the cabinet 1 is a rotary drum 5 which is a container for clothing, in which clothing to be dried is placed. The rotary drum 5 consists of a front wall portion 8 having an opening 6 and perforations 7 surrounding the opening 6, a rear wall portion 10 having perforations 9 provided in circle, and a cylindrical peripheral wall portion 11 interconnecting the front wall portion 8 and the rear wall portion 10. Thus, the rotary drum 5 is formed into a cylindrical shape. Three lifters 12 are secured to the inner surface of the cylindrical peripheral wall of the rotary drum 5 as well as to the inner surfaces of the front wall portion 8 and the rear wall portion 10. A door 13 is provided on the front panel 2 of the cabinet 1 for closing the opening therein, which is adapted to take the clothing into or from the cabinet 1. A front face 14 of the door 13 is substantially flush with the surface of the front panel 2. Thus, the clothing is placed into or taken out from the drum 15 by opening the door 13.

Mounted in the lower portion of the cabinet 1 is a motor 15, which is rigidly secured in position on the bottom surface of the enclosure member 4 of the cabinet 1 by using vibration-preventive rubber mounts 16. The motor 15 transmits its power through two shafts 17, 18 extending on the opposite sides thereof, respectively. A belt 19 is trained around the cylindrical outer peripheral wall 11 of the rotary drum 5, so that power is transmitted from the motor 15 through the belt 19 to the rotary drum 5. Another belt 20 is trained around a pulley on the shaft 18 of the motor 15 and that of the shaft of a blower means or fan 21, so that power is transmitted from the motor 15 through the belt 20 to the fan 21 for rotating same.

Supported by supporting member 25 on the side opposite to the motor 15 but below the rotary drum 5 is a heat generating means in the form of a PTC thermistor 24. The thermistor 24 is placed within a duct 23 having an opening 22 adapted to introduce air therethrough. The PTC thermistor 24 provides a Curie temperature of about 175°C so as to prevent firing, even if the dust of clothing contacts the PTC thermistor during the drying process of clothing. In other words, the PTC thermistor generates heat in a man-

ner to suppress its own temperature below about 175°C. Cool air introduced from the exterior is heated by means of the PTC thermistor 24 and then the air thus heated is introduced along a passage 26 which is defined by the front wall portion 8 of the rotary drum 5 and the members 27, 28, so that the aforesaid heated air is introduced towards the perforations 7 in the front wall portion 8 of the rotary drum 5. The passage 26 is so designed as to surround the perforations 7 in the front wall portion 8 of the rotary drum 5 at its end, i.e., in a concentric relation thereto. A shielding plate 29 is positioned between the duct 23 and the rotary drum 5. A front felt bearing 30 is interposed between the projecting circular edge of the front wall portion 8 of the rotary drum 5, which defines the opening 6, and the projecting edge of a member 28, so that the felt bearing 30 supports the rotary drum 5 thereon. A door packing 31 is provided on the front panel 2 interiorly of the door 13 on the side of the rotary drum 5.

On the other hand, a filter 32 of a cup shape having holes is provided within the rotary drum 5 in the rear thereof in contiguous relation to the projecting portion of the rear wall portion 10 of the rotary drum 5, thereby collecting dust of clothing thereon. Interiorly of the filter 32, there is provided a lint filter 33. A fan casing 34 is provided between the rear wall portion 10 of the rotary drum 5 and the rear panel 3 of the cabinet 1 for housing the fan 21 therein, while the fan 21 is secured to a bearing portion 35, around which is trained the aforesaid belt 20.

The fan casing 34 is formed by the members 36 and 37.

An exhaust port 38 extends through the upper portion of the rear panel 3 of the cabinet 1, so that air from the rotary drum 5 is exhausted to the outside of the cabinet 1 therethrough. Interposed between the rear wall portion 10 of the rotary drum 5 and the member 36 is a rear felt bearing 39 which surrounds the perforations 9 defined in the rear wall portion of the rotary drum 5, and thus the felt bearing 39 supports the rotary drum 5 thereon.

Placed on top of the front panel 2 of the cabinet 1 is a control device, while a timer knob 40 is provided on the outer surface of the front panel 2.

Secured to the bottom surface of the enclosure member 4 of the cabinet 1 are supporting legs or supports 41, which support the drier thereby. Interposed between the member 28 and the rotary drum 5 is a felt seal 42.

Now, description will be turned to the operation of the clothes drier, which embodies the present invention. First, the door 13 is opened so as to place the clothing to be dried, into the rotary drum 5, and then the door 13 is closed. Subsequently, the timer knob 40 is turned so as to start the motor 15, thereby rotating the rotary drum 5 through the medium of the belt 19 as well as to feed a current to the PTC thermistor 24.

At this time, the rotary drum 5 is thus rotated, while the fan 21 is rotated by the medium of the belt 20, thereby introducing air from the exterior of the cabinet 1. Air is introduced under suction by means of the fan 21 and fed towards the PTC thermistor 24, so that air is heated to give a desired heating value at a given flow rate. In this manner, cool air is introduced into the rotary drum 5 according to the suction of the fan 21 and heated by the PTC thermistor 24 instantaneously, when passing by the thermistor 24. In this respect, the PTC thermistor 24 is not red hot as in the case of the ferrochrome wire heater, and the air is subjected to the heat exchange thereat. The air which has been heated by the PTC thermistor 24 is introduced through the passage 26 and the perforations 7 in the front wall portion 8 of the rotary drum 5, then into the rotary drum 5, for drying the clothing. Thereafter, the air passes through the filter 32 and lint filter 33 attached to the rear wall portion 10 of the rotary drum 5, then through the exhaust port 38 to the exterior of the cabinet 1, as exhaust air streams.

It should be noted, however, that the PTC thermistor 24 as used herein as a heat source raises its temperature, when the quantity of air passing through the rotary drum 5 is increased, and lowers its temperature, when the quantity of air passing therethrough is lessened, thus permitting the adjustments of the flow rate of air as well as the temperature.

After the lapse of a given time, the clothing placed therein is found dried, and then the switch is cut off, thereby completing the drying process of clothing itself. Then, the door 13 is opened to take out the clothing from the drier, completing the entire process of drying of the clothing.

Figure 2 shows the outline of the construction of the clothes drier. Assume that Ta is atmospheric temperature, and Td a temperature of exhaust air, when air is exhausted through the exhaust port 38, after the air heated by the PTC thermistor 24 has dried the clothing within the rotary drum 5; Q (m^3/min) a flow rate of air being introduced under suction; and P (watts) an input (heating value) of the PTC thermistor 24. The exhaust air temperature follows a curve A shown in Figure 3 at the varying drying times (min.). In a portion B of the curve A, there takes place heating in a drying chamber as well as evaporation of moisture. While in a portion C which runs substantially in the horizontal

direction, there results an equilibrium between the input and the evaporation of moisture and hence drying. The point D represents the completion of drying of the clothing up to about 90%, while a point E represents the completion of drying up to about 100%.

Meanwhile, reference is made to the temperature difference ΔT between the exhaust air temperature Td and the atmospheric temperature Ta. $\Delta T = Td - Ta$, wherein ΔT denotes a temperature rise of the exhaust air temperature Td from the atmospheric temperature Ta which is taken as a reference temperature in this case. In this case,

the heating values per hour generated in the heat generating device $= 60\ P/J$ (1)

Thermal energy of air $= C_p . g . Q . \Delta T$ (2)

wherein

g: air density (gram/m^3)
J: work equivalent of heat (Joule/calory)
C_p: specific heat at constant pressure of air (calory/gram °C)

Then,

$$60\frac{P}{J} = C_p . g . Q . \Delta T,$$

$$\Delta T = \frac{60P}{C_p . g . Q . J} \quad (3)$$

Thus, ΔT may be expressed as in the formula (3).

Here now, the formula (3) is substituted by numerical values, i.e. $J = 4.1855$ (Joule/calory), $g = 1.29 \times 10^3$ (gram/m^3) (at 0°C and 1 atmospheric pressure), and $C_p = 0.24$ (calory/gram °C), then the formula (3) is expressed as follows:

$$\Delta T = 4.63 \times 10^{-2} \times P/Q \quad (4)$$

Stated otherwise, the exhaust air temperature rise ΔT (the temperature difference between the exhaust air temperature Td and the atmospheric temperature Ta) may be expressed as the function of an input P of a heat source and the flow rate Q of air, as given in the formula (4). On the other hand, the input P of the heat source of a drier and the flow rate Q of air is predetermined during design of the drier, while the temperature rise at the completion of drying is constant, regardless of the kinds and quantities of the clothing to be dried. Thus, detection of this temperature difference enables the automatic control for the completion of drying.

Figure 4 represents the temperature differences ΔT between the temperature at the time of the completion of drying the clothing up to 90% dry and the terminating point of the temperature rise at the completion of drying the clothing up to 100% dry. In this connection, T_1 represents the temperatures at the completion of drying up to 100%, in the case of cotton of 2 kg, T_2 similarly represents the temperature in the case of synthetic fibers of 2 kg, T_3 similarly represents the temperature in the case of cotton of 1 kg, and T_4 similarly represents the temperature of synthetic fibers of 1 kg, at the completion of drying up to 100%, respectively. The respective starting points (x) connecting with T_1, T_2, T_3, T_4 by the chain lines represent the times and temperatures at the completion of drying up to 90%. As shown, T_1, T_2, T_3, T_4, times of completion of drying, vary depending on the types and quantities of the clothing to be dried, and so does the exhaust air temperature curve. The temperature rise ΔT of the exhaust air temperature is found to be in the range of $32° \pm 5°$. In other words, assume the temperature rise T of exhaust air in the general case, then the aforesaid temperature rise ΔT falls in the range of $T° \pm t°$, namely $\Delta T = T° \pm t°$, presenting a substantially constant value.

Figure 5 shows an electric circuit diagram of the clothes drier and shown at 50 is a door switch, at 51 a starting switch, and at 53 relay contacts which are to be closed, when the relay 52 is excited, and to be opened when the relay 52 is de-energized. Shown at 55 is a transformer, at 56 a diode, at 57 a condenser, at 58 relay, at 59 relay contacts which are to be opened when the relay 58 is excited, but normally closed. The heater 24 in the form of a PTC thermistor is connected in parallel with one of the windings of the transformer 55. Shown at 60, 61, 62 are transistors, at 63 a condenser, 64, 65, 66, 67, 68a, 68b are resistors. Shown at 69 is an atmospheric-temperature-detecting thermistor having a negative temperature coefficient, at 70 an exhaust-air-temperature-detecting thermistor having a negative temperature coefficient. Both thermistors 69 and 70 have the same temperature characteristic. The atmospheric-temperature-detecting thermistor 69 is attached to the outer surface of the cabinet 1 to detect atmospheric temperature, while the exhaust-air-temperature-detecting thermistor 70 is attached within the exhaust port 38 to detect the air temperature in the exhaust port. Shown at 71 is a power source.

Constituting a bridge circuit are the atmospheric-temperature-detecting thermistor 69, exhaust-air-temperature detecting thermistor 70, and two resistors 68a, 68b. Assume that the resistances of the thermistors 69, 70 are $R_1(t)$ and $R_2(t)$ ohms, respectively 't' denotes the temperature which is the function of the resistance) and that the resistance of each

resistor 68a, 68b is R ohms. In addition, assume that a current impressed on the bridge circuit is I amperes. The resistance r between G and H is negligible. The current i flowing between G and H may be given according to the Kirchhoff's law, as follows:

$$i = \frac{IR[R_2(t)-R_1(t)]}{[R_1(t)+R]\,[R_2(t)+R]+r[R_1(t_1)+R_2(t)+2R]} \quad (5)$$

As has been described earlier, r is negligible, so that

$$i \doteqdot I\frac{R_2(t)-R_1(t)}{R_2} \cdot \frac{1}{[1+\frac{R_1(t)}{R}]\,[1+\frac{R_2(t)}{R}]} \quad (6)$$

In other words, the exhaust temperature rise ΔT may be obtained as a variation in the current i of the formula (6), or as the variation in the current I, as well. Accordingly, at the time of starting, a current flows, as shown by an arrow, through the thermistor 69, point G, point H and resistor 68b, and on the other hand, when the exhaust air temperature gives a temperature rise ΔT when ΔT is 30°C, e.g. Td is 40°C and Ta is 10°C, or Td is 55°C and Ta of 25°C), the current flows through the exhaust-air-temperature-detecting thermistor 70, as shown by an arrow, while the current thus flowing is amplified by the transistors 60, 61, 62 to thereby excite the relay 58 so as to open the relay contacts 59, with the resulting automatic stoppage of the drier. In case of the cotton and the like which require a longer drying time than the synthetic fibers, or in case the amount of clothing to be dried is considerable, then there results a longer drying time. However, when ΔT reaches a given temperature rise, then drying will be completed and hence the operation of the drier will be stopped. Meanwhile, other type heat sensitive members may be used in place of thermistors 69, 70, other than thermostats.

Figure 6 shows a characteristic curve representing the relationship between heating value by PTC thermistor used as a heat source and the air flow Q. On a portion F of the curve, i.e. in the range of the air flow of 0.3 to 0.9 m^3/min, the heating value P is in approximate proportion to the air flow Q. As a result, if the air flow Q is reduced due to the clogging in a filter, then the heating value P is reduced in proportion to the reduction in the air flow Q. Thus, in case the atmospheric temperature Ta, the exhaust air temperature Td, and the exhaust air temperature rise ΔT are known or detected, upon drying the clothing, then a proper drying condition or results may be achieved with the temperature difference ΔT maintained constant.

Figure 7 shows a characteristic curve illustrative of the relationship between the ratio of the heating value P by the PTC thermistor used as a heat source to the air flow Q, and the air flow Q itself. Due to the clogging in the filter and the stoppage of a blower means, if the air flow Q is almost reduced to zero, then the ratio P/Q will be increased sharply, so that the resistance is steeply increased with the resulting steep decrease in the quantity of heat being generated.

In this manner, there is achieved a clothes drier, which is simple in construction and avoids setting the drying time by means of the timer, as in the conventional dryer, yet permitting proper drying, even if there takes place clogging in the filter, and which enables the positive automatic drying. In addition, there is achieved a clothes drier, which automatically prevents the overheating by the use of a heat source which generates heat so as not to exceed a given temperature, while dispensing with a thermostat as used in the conventional drier for the purpose of preventing the overheating, thus presenting high safety.

In addition, there is achieved a clothes drier which dispensed with a protective means such as a thermostat and which in case the air flow was reduced, releases a heat source automatically and electrically, thereby presenting ease in handling.

Yet furthermore, there is achieved clothes drier, which even if a dust clothing contacts the surface of the heat generating means during a drying process, there is no possibility of firing.

Still furthermore, there is achieved a clothes drier, which allowed the use of air streams at a lower temperature within the rotary drum, thus dispensing with a thermostat for use in adjustment of temperature, and which is high reliability.

WHAT WE CLAIM IS:—

1. A clothes drier, comprising: a cabinet; a container which is rotatably supported within said cabinet, and has an opening; drive means for rotating said container provided within said cabinet; blower means for feeding air from the exterior of said cabinet into said container and connected to said drive means; heat generating means including electrically resistive means for heating air being intro-

duced into said cabinet by means of said blower means and for generating heat of a quantity proportional to a predetermined range of quantity of air being introduced, whereby said heat generating means provides an adjustable temperature of said heat generating means and of heated air exhausted from said container for preventing overheating of said heat generating means and clothes in said container without requiring thermostats; and exhaust means for discharging heated air from said container outside of said cabinet.

2. A clothes drier as claimed in Claim 1, in which the electrically resistive means has an operating characteristic which is such that the ratio of the quantity of heat generated, to the quantity of air fed, is increased when the quantity of air fed is reduced.

3. A clothes drier as claimed in Claim 1 or Claim 2, wherein said drier further comprises: means for detecting an atmospheric temperature outside of said cabinet; means for detecting exhaust air being exhausted from said exhaust means; and means for de-activating said heat generating means, when the difference between said atmospheric temperature and said exhaust air temperature thus detected reaches a given exhaust air temperature rise or difference at the completion of drying of said clothing.

4. A clothes drier as claimed in any one of the preceding Claims wherein the heat generating means comprises a PTC thermistor.

5. A clothes drier substantially as hereinbefore described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1978
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

FIG. 1

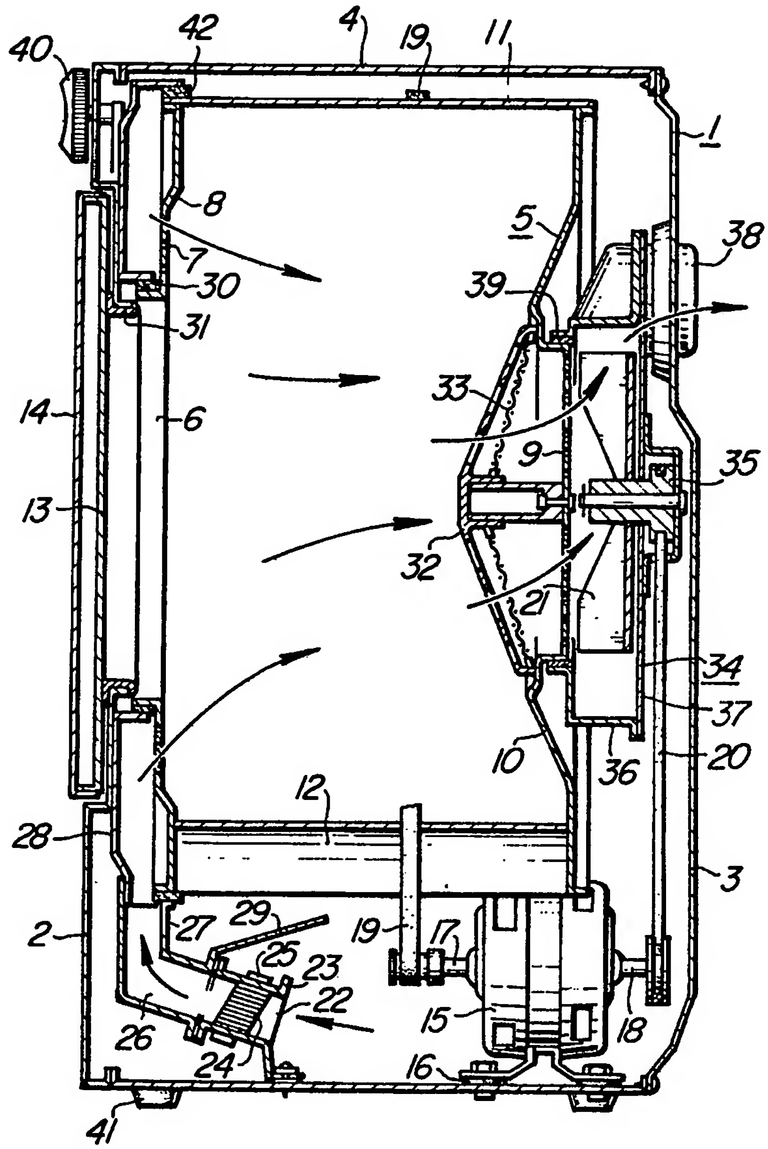
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FIG. 2

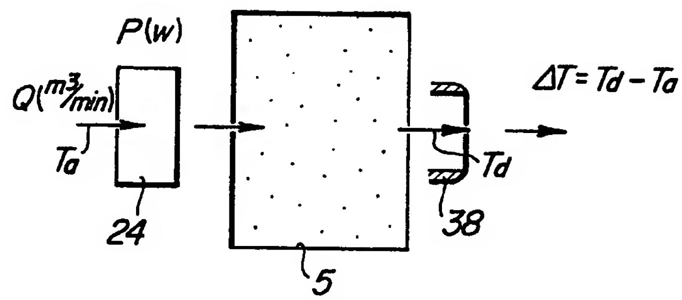
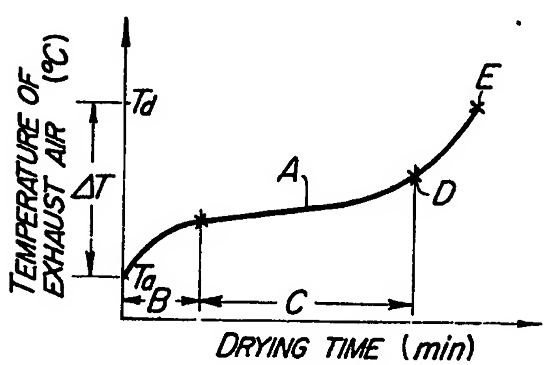

P(w)
Q(m³/min)
Ta
24
5
Td
38
ΔT = Td − Ta

FIG. 3


TEMPERATURE OF EXHAUST AIR (°C)
Td
ΔT
Ta
A
D
E
B
C
DRYING TIME (min)

1 502 919 COMPLETE SPECIFICATION

4 SHEETS This drawing is a reproduction of the Original on a reduced scale.

SHEET 3

FIG. 4

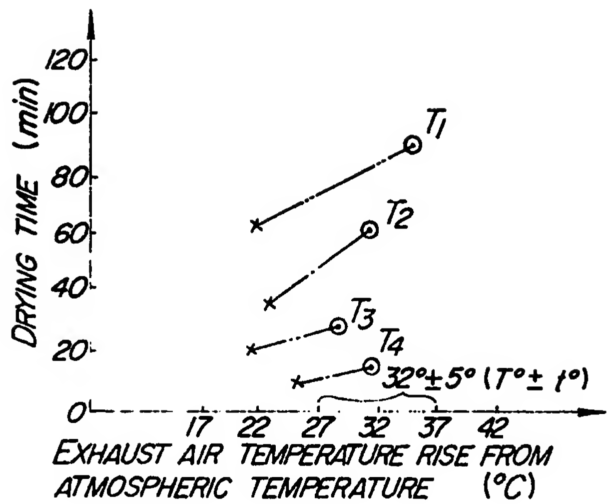


FIG. 5

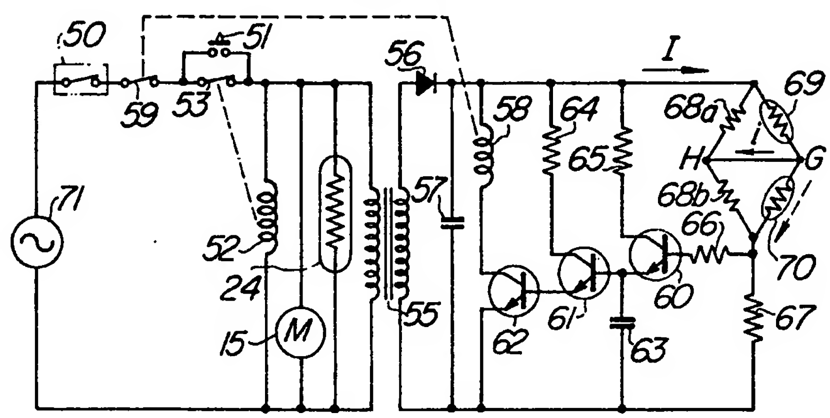


FIG. 6

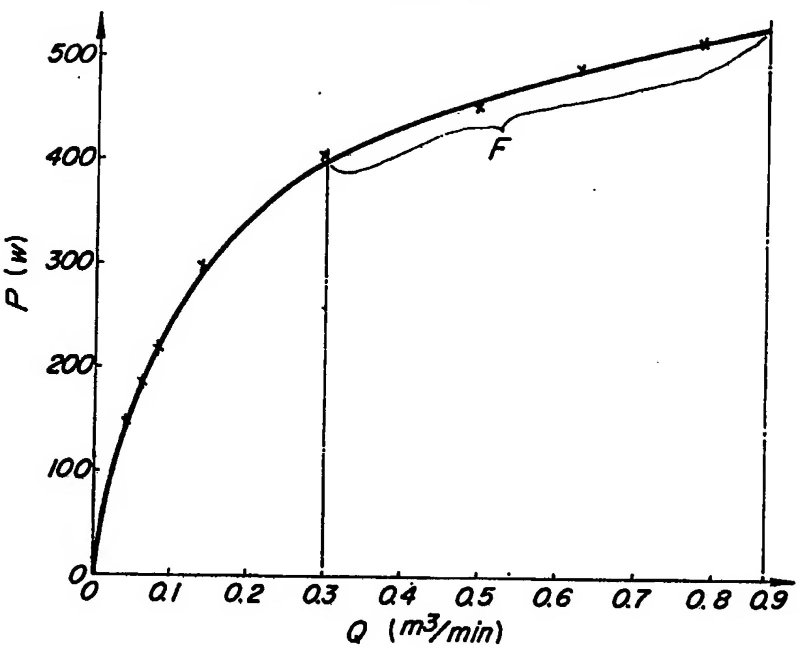
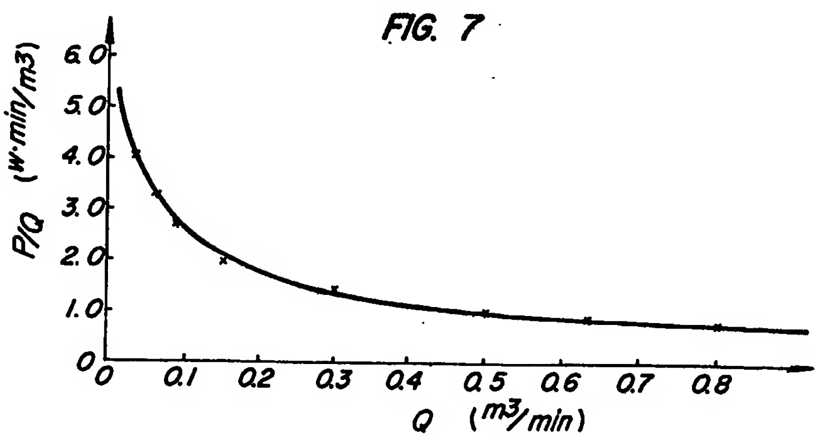

500
400
300
200
100
0
P (w)
F
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Q (m³/min)

FIG. 7


6.0
5.0
4.0
3.0
2.0
1.0
0
P/Q (w·min/m3)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Q (m³/min)